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CENTRAL PLANTATION CROPS RESEARCH INSTITUTE
KASARAGOD 670 124, KERALA, INDIA

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IDENTIFICATION OF PREPOTENT PALMS IN WEST COAST TALL VARIETY BASED ON GROWTH OF PROGENY IN THE NURSERY

K. SATYABALAN AND JACOB MATHEW

Central Plantation Crops Research Institute, Kasaragod - 670 124, Kerala State, India

Nursery observations on growth rate and seedling vigour as measured by girth at collar and leaf production recorded every month from the time of germination in 599 open pollinated progenies of 16 selected palms of the local West Coast Tall variety showed highly significant differences in growth rate of progenies between families. Rate of growth increased from fifth month in progenies of certain families. Correlations of these growth characters from the first to ninth month with those of the tenth month indicated high and positive correlation from fifth month onwards thereby showing that it might be possible to identify palms of superior genetic value (prepotents) from even fifth month. In this way, it may be possible to screen large numbers of palms for prepotency. These studies also indicated that in areas where young seedlings are preferred for planting, when selection of vigorous growing ones becomes difficult, it is preferable to select seedlings at five months' age based on growth characters like collar girth and leaf production.

ANALYSIS OF THE COMPONENTS OF THE COCONUT — STUDY OF SAMPLING

J. MEUNIER, R. ROGNON, AND M. de NUCE de LAMOTHE

Institut de Recherches Huiles et Oleagineux, 11 Square Petrarque 75016, Paris, France

In order to fix the minimum sampling size which would determine the average composition of nuts of a tree or a group of trees, all the nuts produced during three years by two variable populations of coconut palms of West African Tall and Polynesian were systematically analysed for seven characters, viz, weight of nut, weight of de-husked nut, weight of husk, weight of water, weight of shell, weight of albumen, and weight of copra.

Except for weight of water and husk, one year's observation was found to be enough to compare trees or lines planted in the same trial. However, because of seasonal and annual variations, to obtain absolute values, it would be necessary to observe four nuts every two months for two or three years to characterize one tree, and one nut every two months of 50 trees for 5 - 6 years to estimate the variability of a line.

It may be possible to reduce these for more homogeneous material as hybrids or self-fertilized dwarfs.

SELECTION AND BREEDING OF DWARF COCONUTS WITH SPECIAL REFERENCE TO INDIAN DWARF ORANGE PALMS AND THEIR NATURAL HYBRIDS

C. A. NINAN

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The Dwarf Orange coconuts of the west coast of India have long been known to produce a proportion of semitall progenies from seeds obtained after open pollination. They are believed to be products of outcross with Talls though they can be obtained after selfing Dwarfs also. Data are presented to show that such progenies are superior to West Coast Tall palms in yield of nuts, copra content per nut, and percentage of trees in high yielding group in different populations.

Progeny row studies have revealed the existence of significant variation among individual palms in germination percentage of nuts and recovery of natural hybrids and segregants. A trend for linear increase in percentage of such seedlings with increase in seed weight was also observed. It is suggested that by selecting Dwarf seed parents for high germinability of seed nuts and high recovery of colour variants (segregants and D x T hybrids) the hybrid programme could be made more viable. Further by evolving suitable criteria for identifying legitimate hybrids in the progeny and constructing selection indices for seedling characters for picking up superior planting material among hybrids, the whole programme could be geared for improving yields of future plantations of these hybrids. Better recovery of hybrids and segregants could be obtained from mixed seed gardens of Dwarfs and Talls by discarding those Dwarf mother palms which show high failure of germination and death of young sprouts and producing a high percentage of pure Dwarf seedlings. In situations where elaborate operations like emasculation and assisted or deliberate pollination with Tall pollen are not possible, the recovery of hybrids and segregants could be increased by discarding nuts with lower seed weights.

XENIA AND COMBINING ABILITY IN THE COCONUT PALM

F. ROGNON AND M. de NUCE de LAMOTHE

Coconut Breeding Department, IRHO Station, Port Bouet, Ivory Coast

The influence of pollen parent on endosperm characters was studied. Forty-five Cameroon Red Dwarf mother trees were divided into three groups and fertilized with pollens of (1) Cameroon Red Dwarf (Control); (2) West African Tall (copra/nut : 200-205 g) ; and (3) Tahiti Tall (Copra/nut : 311 g).

The copra/nut obtained from the three crosses were: (1) Control, 220 g; (2) 258 g; and (3) 260 g. These results show a very significant effect of the pollen parent on copra/nuts. The results of the second cross suggest a possible effect of heterosis.

Amongst the other characters observed the relationship, $R = \frac{\text{endosperm} \times 100}{\text{(husked fruit} - \text{water)}}$ was very significantly above the control in the latter. It is probably the same as for copra oil content.

Finally, the shell weight was also significantly more than that of the control in the second and third crosses, but as the shell is a maternal tissue, the phenomenon remains to be explained.

THE MECHANICS OF HYBRID SEED PRODUCTION THROUGH SEED GARDENS

M. A. P. P. MANTHRIRATNE

Coconut Research Institute, Lunuwila, Sri Lanka

In the establishment of isolated seed gardens for hybrid seed production, the correct balance between Dwarf (seed) parents and Tall (pollen) parents has to be maintained. Excess Tall (pollen) palms would be a luxury in view of the space they occupy which could otherwise be planted up with Dwarfs. On the other hand, too few or badly distributed (pollen) palms may lead to reduced seed set.

Data are presented on three types of distribution patterns: (a) compact block of Dwarfs surrounded by Tall palms; (b) alternating rows of Dwarfs and Talls; and (c) Dwarfs and Talls in the ratio of 25 : 3. The techniques of emasculation that are now adopted minimise the risk of pure Dwarf progenies. This is vital because if both parents of the hybrids are green, they would furnish no reliable means of distinguishing a hybrid seedling from one due to a chance selfing of a Dwarf. Data relating to production and legitimacy of Dwarf × Tall natural cross hybrids (as judged by nursery studies) are presented.

COCONUT IMPROVEMENT BY SELECTION AND BREEDING — A REVIEW IN THE LIGHT OF RECENT FINDINGS

K. V. A. BAVAPPA AND C. K. SUKUMARAN

Central Plantation Crops Research Institute, Kasaragod 670 124, Kerala State, India

Coconut improvement programmes have been reviewed in the light of the recent data collected on this aspect. The major breeding objectives have been identified as higher yield of oil per unit area of coconut plantation and resistance/tolerance to serious diseases such as Root (wilt), 'Thattipakka' and Stem bleeding.

The breeding system varies widely both in Tall and Dwarf cultivars. The usefulness of studying the inheritance of this character and the possibility of realising stable hybrids have been discussed. The advantage in selecting the best 10% of palms in a given population as mother trees both for seed nut collection and for breeding purposes has been brought out. Selfing of the West Coast Tall variety palm has confirmed the earlier observation that it is heterozygous for height while Chowghat Dwarf Orange variety is heterozygous for colour, vigour and stature. Lines which breed true for these characters are also present in the population. In addition to wide variation in vigour, segregation for colour was also observed among the heterozygotes realised by selfing or open pollination of Dwarf Orange or by crossing Dwarf Orange with Tall. Studies on the relationship between yield of nuts, copra content per nut, total yield of copra per palm, and yield of oil per palm showed that in West Coast Tall the mean copra content per nut, though negatively correlated with yield, does not affect annual outturn of copra per palm and that the yield of oil per palm and yield of nuts are significantly and positively correlated. The necessity for exercising selection pressure on weight of copra per nut and oil percentage in addition to number of nuts has been indicated keeping in view the variability and heritability data available for these characters.

Further experiments to be taken up for a better understanding of the genetic make up of the Tall and Dwarf varieties, the different approaches that may be pursued for improving their genetic base and the possibilities of realising a higher percentage of hybrids in the Dwarf x Tall crosses are discussed in the light of the available data.

Cytology

CYTOGENETIC AND GENETIC STUDIES IN COCONUT: A REVIEW

P. K. THANKAMMA PILLAI, G. VIJAYAKUMAR, AND M. C. NAMBIAR

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Kerala State, India.

The chromosome number in coconut is 2n = 32. Karyomorphological studies show slight differences between Tall and Dwarf palms. Meiosis is generally regular in Tall cultivars and in hybrids between Tall and Dwarf, while several irregularities have been reported in the Dwarfs and semitall varieties. Pollen fertility is very high in Talls and hybrids as compared to that in Dwarfs and the semitalls. Dwarfs and Spicata may owe their origin from the Tall as a consequence of inbreeding resulting from a self-pollination. Inbreeding depression has been noted in most of the selfed progenies of Tall cultivars. Heterosis is reported in almost all the cross breeding trials.

The genetic component of factors affecting yield has been estimated to be 49% by one method and 62% by another. The high phenotypic value of seed parent

may be due to the additive or non-additive effects of genes. Since considerable genetic variation is available for selection in the West Coast Tall, selection of trees having characters of low heritability superimposed with high set can help in bringing about yield improvement by mass selection. The selection of mother palms with high yield in hybridization work or for progeny testing appears to be reliable. The selection of genotypes with low variance for distribution of female flowers and a large number of spikes each with a single female flower may also help to improve and stabilise yield.

GENETIC POTENTIAL OF SOME COCONUT POPULATIONS IN THE PHILIPPINES

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Six Tall and two Dwarf coconut populations were observed to identify their genetic potentials. The rate of fruit set varied inversely with the number of female flowers. 'Tagnanan' and 'Baybay' populations give meat ÷ nut less water ratios of 0.46 and 0.44, and highest copra per nut (304 g and 288 g, respectively). Copra per nut of 'Catigan' and 'Tacunan' populations at 209 g and 213 g were unusually high for Dwarf populations.

The male phase of 'Catigan' lasted for 24.6 days and of 'Tacunan' for 23.3 days. Their female phases lasted 8.6 and 8.1 days, respectively. It is definite that self-pollination occurs on both populations. Intra-inflorescence overlap of male and female phases on 'Catigan' lasted for 6.6 days and 'Tacunan' for 4.6 days. The mode of pollination is semi-direct; more or less complete overlapping of the female phases partly by the male phase of the same inflorescence (n) and partly by the male phase of the following inflorescence ($n + 1$). A simultaneous overlap within inflorescence n, and between n and $n + 1$ can also occur.

IMPROVEMENT OF COCONUT IN PAPUA NEW GUINEA

J. SUMBAK

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By the end of 1976 about 35 hectares of Malayan Dwarf mother palms will have been planted out in Papua New Guinea's hybrid seed programme. Hybrid seed is expected to become available early in 1979. Trials under way at Keravat (New Britain) and Bubia (New Guinea mainland) will determine the appropriate male parent (s).

Growth measurements taken 18 months from field planting clearly showed the superiority of hybrid seedlings over tall types. At Bubia, the Dwarf x Rennel Island hybrid was outstanding. Its uniformity was particularly striking and first flowering is expected within 30 months of field planting. The Dwarf x Gazelle Tall also performed well and the Dwarf x West African Tall hybrid looked impressive desp te the fact that nursery selection was not possible All the Tall types were inferior to all the hybrids. The Kar Kar Tall source suffered very badly from *Drechslera* leaf spot at Bubia and there is no doubt that this genotype is particularly vulnerable to this disease. At Keravat where *Drechslera* did not constitute a severe problem the Kar Kar type appears to be above average. It was superior to all the tall types except Rennel Island.

Blocks of potential male parents have been established at Bubia and Keravat while additional hybrids (particularly Dwarf x Kar Kar and Dwarf x Markham) will be tested.

AGRONOMY AND SOIL CHEMISTRY

Tuesday Afternoon
28–12–1976

1. I Henry Louis and NR Chandrasekar, Tamil Nadu Agricultural University, Subcentre, Veppankulam 614 906, Tamil Nadu, India.

2000 words — Effect of cultural, manurial, and cultural operations on coconut palm in Tamil Nadu.

2. V Abeywardena, Coconut Research Institute, Lunuwila, Sri Lanka.

2000 words — Effect of moisture stress and irrigation on yield of coconut.

3. RS Murthy, NK Barde, SR Nagabhushana, KR Venugopal, CR Shiva Prasad, and CS Harindranath, National Bureau of Soil Survey and Land Use Planning, Regional Centre, Hebbal, Bangalore 560 024, Karnataka, India.

2000 words — Soils of coconut areas in *Maidan* parts of Karnataka State, India.

4. CB Kamala Devi, M Velayutham, and M Haridasan, Central Plantation Crops Research Institute, Kasaragod 670 124, Kerala State, India.

2000 words — Soil and leaf analysis in relation to the nutrition of high yielding coconut genotypes.

5. K Ramadasan, T Vanialingam, Edward Chan, KC Tech, and I Abdulla, Malaysian Agriculture Research and Development Institute, Cacao and Coconut Branch, Teluk Anson, Malaysia.

2000 words — Intercropping coconuts with cacao in Malaysia.

6. UP Bhaskaran and K Leela, Kerala Agricultural University, Agronomic Research Station, Chalakudy 680 307, Kerala State, India.

2000 words — Seasonal influence on yield of Tall × Dwarf and WC Tall Coconuts in Kerala State, India.

7. P Loganathan and T S Balakrishnamurthi, Coconut Research Institute, Lunuwila, Sri Lanka.

2000 words — Fertiliser requirements of adult coconut palms in Sri Lanka.

8. NG Pillai, CB Kamala Devi, PA Wahid, and CKB Nambiar, Central Plantation Crops Research Institute, Regional Station, Krishnapuram 690 533, Kerala State, India.

2000 words — Available micronutrient status of major soil types under Coconut in healthy and root (wilt) affected tracts.

9. P Coomans, Institut de Recherches Pour Les Huiles et Oleagineux, Port Bouet, Ivory Coast.

2000 words — The fertilisation of hybrid coconut palms in the Ivory Coast.

10. KN Sahasranaman, NG Pillai, NP Jayasankar, VP Potty, Thomas Varkey, PG Kamalakshyamma, and K Radha, Central Plantation Crops Research Institute, Regional Station. Krishnapuram 690 533, Kerala State, India.

2500 words — Mixed farming in coconut gardens — Economics and its effects on root (wilt) disease.

EFFECT OF CULTURAL, MANURIAL, AND IRRIGATIONAL OPERATIONS ON COCONUT PALM

I. HENRY LOUIS AND N. R. CHANDRASEKAR

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The effect of two levels of cultural, manurial, and irrigational operations on growth characters, spathing and yield of nuts was studied at three and eight years age in a field experiment using a split plot design with three replications.

At three years, manuring increased the height, girth at collar, number of leaves per year, number of leaves on the crown, length of leaves, and the number of leaflets per leaf. Irrigation produced significant increase in height. Cultural operations either alone or in combination with irrigation or manure did not have any effect on growth characters. No interaction between genotype and the treatments was also observed on any of the characters under study.

At eight years, manuring and irrigation together increased the number of leaves and length of stem. Early and uniform flowering and increased yield of nuts per palm were also observed. Irrigation alone increased number of leaves but cultural operations did not produce any significant effect. Interaction was observed only between manure and genotype and in the production of leaf.

EFFECT OF MOISTURE STRESS AND IRRIGATION ON YIELD OF COCONUT

V. ABEYWARDENA

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A coconut inflorescence carries on an average about sixteen female flowers at the time of opening of the spathe. On the average about two-thirds of this number is lost through immature nutfall over the first six months of nut development. Yield variations are due to variations in this immature nutfall arising possibly from inadequate supply of soil moisture.

Work in Sri Lanka has been directed primarily towards establishing a quantitative relationship between rainfall and crop variations and it met with considerable success towards 1967. This enabled us to forecast crops a year ahead with considerable accuracy ($r = 0.93$). Such forecast of crops for a given estate or restricted area involved as much as twelve rainfall variables. A forecast for the whole country on this basis would necessitate the consideration of a number of rainfall stations. This would therefore involve a prohibitively large number of rainfall variables in the production function. To obviate this difficulty a different approach based on "droughtiness" that is, the antithesis of rainfall was adopted.

Forecasts of coconut production in Sri Lanka through this index of droughtiness have been very successful.

As a logical follow up of these investigations, an irrigation experiment wa commenced recently involving supply of different quantities of water at different frequencies to the palms, in order to ascertain how much of this nut loss through immature nut fall could be arrested through watering. Even at this very early stage of the experiment, the watered palms showed significant increases in yield over the control.

SOILS OF COCONUT GARDEN AREAS IN *MAIDAN* PARTS OF KARNATAKA STATE, INDIA

R. S. MURTHY, N. K. BARDE, S. R. NAGA BHUSHANA, K. R. VENUGOPAL, C. R. SHIVAPRASAD AND C. S. HARINDRANATH

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A study of soils from the coconut garden areas in *Maidan* region of Karnataka (parts of Hassan, Tumkur and Bangalore districts) was carried out. The geology of the area consists of Dharwarian schists and peninsular gneisses with younger granites. Generally, the coconut gardens occupy the low lands (valley bottoms, river and stream banks). The soils are deep to very deep alluvial and colluvio-alluvial in origin, light yellowish brown, reddish brown to dark gray brown, coarse loamy to fine loamy, occasionally fine to very fine in some horizons, well drained to moderately well drained, rapid to slowly permeable, non-calcareous or calcareous families of Inceptisols and Entisols. Studies of eleven representative soil series reveal a range of pH between 5.5 to 9.5, low to medium and high moisture retentivity, low to high available potash and potash fixing capacity, presence of felsic minerals and lighter fractions of Bangalore district soils and ferromagnesian suite in the fractions of sand in Hassan and Tumkur district soils, where they are 'made up' by addition of extraneous materials as a part of management practice. A map showing the distribution of coconut growing areas has been prepared.

SOIL AND LEAF ANALYSIS IN RELATION TO THE NUTRITION OF HIGH YIELDING COCONUT GENOTYPES

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Seasonal changes in the nutrient composition of index leaf and available nutrient status on acid sandy loam soil of a ten year old coconut plantation were

evaluated in relation to the mineral nutrition of three high yielding coconut genotypes (West Coast Tall, Tall × Dwarf, and Dwarf × Tall) grown under three levels of fertilisers. Seasonal changes in leaf nutrients status confirmed that the fourteenth leaf could be taken as the index leaf under the local conditions. Available K was the limiting nutrient in this soil which was reflected in deficient K concentration of leaf in control plots. An inverse relationship between K and Mg content of leaf was observed. The leaf concentration of N was not significantly influenced by fertilisation. Even at the highest level of fertiliser application, N content of leaf was below the critical limit proposed by the I R H O. However, yield data indicated that the critical limit might be lowered to suit West Coast conditions. No significant variation was observed in P content of leaves due to fertilisers or genotypes. Fixation of P in the soil appeared to be accentuated during monsoon months. N P K fertilisation increased the concentrations of Mn, Zn and Ca in the leaf while those of Ca, S, Fe, B and Mo were unaffected.

INTERCROPPING COCONUTS WITH COCOA IN MALAYSIA

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Intercropping offers an effective solution to the problem of increasing productivity of existing coconut areas in Malaysia.

Coconut is grown as a monocrop on fertile alluvial clays in a large acreage of land on the west coast of peninsular Malaysia. A considerable proportion of this area can be underplanted with cocoa. Small-scale trials in the fifties were highly encouraging. Large scale commercial cocoa plantings under coconuts had become a reality by the mid sixties. A boost to this cropping system has been given by the favourable prices for cocoa beans in recent years, coupled with low and unstable economic returns from coconut monoculture and the provision of a ready-made shade system. Intercropping accounts for a major part of the rapid expansion of the cocoa industry in the country.

The present situation with respect to planting materials, cultural practices, fertiliser inputs, pests and diseases, harvesting and processing, as well as yields and profitability is considered and the main areas of research are discussed.

The establishment of new coconut plantings derived from high yielding hybrid materials could significantly enhance the potential of this cropping system.

SEASONAL INFLUENCE ON YIELD OF TALL x DWARF AND WEST COAST TALL VARIETIES OF COCONUT

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Influence of rainfall, its distribution, temperature, sunshine, and humidity on the yield of Tall x Dwarf and West Coast Tall varieties of coconut were studied for 22 years on a population of 40 palms per variety, at the Coconut Research Station, Nileshwar, under rainfed condition. The yield and quality of nuts varied distinctly in the three climatic seasons of Kerala. In both the varieties maximum number of bunches were harvested during the hot weather and lowest during north-east monsoon. Percentage of aborted spadix was maximum during the harvest in South-West monsoon. Female flower production was maximum in bunches harvested during hot weather period and lowest in North West monsoon period. Percentage of button setting was not much affected by the seasons. Favourable weather condition in the early stages of nut development and kernel formation ensures big sized nuts with high copra and oil content.

Yield fluctuation due to seasonal variations was less in Tall x Dwarf hybrids, high yielding trees of West Coast Tall, and in regularly cultivated and manured palms. Seasonal yield variations were also less pronounced in laterite soil than in red sandy loam and littoral sand.

It is inferred that a more uniform crop of good quality nuts can be taken throughout the year by relieving the crop from moisture stress and desiccation effect during the critical stages of spadix development. This can be achieved to a great extent by providing irrigation in the dry periods.

FERTILISER REQUIREMENT OF ADULT COCONUT PALMS IN SRI LANKA

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Field experiments carried out on adult palms under different soil and climatic conditions showed that coconut responds to the application of N, P, and K fertilisers. Based on these experiments three fertiliser mixtures are proposed for manuring adult coconuts — two mixtures to suit the soil conditions in the Wet and Intermediate Zones and the third for the Dry Zone. The proposed annual recommendations per palm are : Wet and Intermediate zones – (a) 1.4 kg sulphate of ammonia + 0.8 kg rock phosphate + 1.8 kg muriate of potash ; (b) 1.1 kg sulphate of ammonia + 0.9 kg rock phosphate + 1.1 kg muriate of potash ; Dry zone – 1.4 kg sulphate of ammonia + 0.5 kg double super phosphate + 1.1 kg muriate of potash. Statistical methods employed in the derivation of the fertiliser recommendations from the experimental data are discussed.

AVAILABLE MICRO NUTRIENT STATUS OF MAJOR SOIL TYPES UNDER COCONUT IN HEALTHY AND ROOT (WILT) AFFECTED TRACTS OF KERALA

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A survey of coconut plantation in Kerala State was carried out. In this, 733 surface soil samples were collected at about 6.5 km intervals and analyzed for available micro nutrients in five major soil types. Because of the low values encountered in a majority of cases, the following soil types are more likely to be deficient of certain elements : coastal sandy and reclaimed marshy soils for Mn, sandy loam soils for Zn, sandy loam and coastal sandy soils for Mo, and coastal sandy soils for B. The distribution of available Cu was uniform in the different soil types excepting coastal sandy soils.

The root (wilt) disease affected tracts showed a significant reduction in the levels of the following micronutrients as compared to healthy tract: Fe, Mn, and Zn in laterite, reclaimed marshy, and coastal sandy soils ; Zn in alluvial soils ; and Mn and Zn in sandy loam soils. The variation in Cu, B, and Mo content in the different soil types between healthy and disease affected tract was negligible.

The intensity of deficiency of Mo, Zn, and Mn was 83, 48, and 48 per cent, respectively. The intensity of deficiency of Zn was above 47 per cent in all soil types in only the disease affected tract and that of Mo above 60 per cent in both healthy and disease affected tracts.

THE FERTILISATION OF HYBRID COCONUT PALMS IN THE IVORY COAST

P. COOMANS

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Mineral nutrition experiments carried out at Port Bouet in sandy soils with low mineral element content have shown that it is necessary to apply a balanced fertiliser containing N, K, and Mg to hybrid coconut palms from the time of planting. Fertilisers can be classified in the following descending order : Potassium chloride, kieserite and urea. They have a benefic al effect on vegetative development, induce earliness of flowering and help to attain yields of 3,400 kg copra per hectare in year n5 (from $4\frac{1}{2}$ to $5\frac{1}{2}$ years). The results of the experiments have made it possible to prepare a provisional manuring schedule for the hybrid coconut variety Port Bouet No. 121 for the agroclimatic conditions of south-eastern Ivory Coast.

MIXED FARMING IN COCONUT GARDENS – ECONOMICS AND ITS EFFECTS ON ROOT (WILT) DISEASE

K. N. SAHASRANAMAN, N. G. PILLAI, N. P. JAYASANKAR, V. P. POTTY, THOMAS VARKEY, P. G. KAMALAKSHYAMMA, AND K. RADHA

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The mixed farming programme consisted of cultivation of fodder grasses and legumes in the interspaces of coconut, maintaining milch cows and recycling of cattle wastes. The economics of this practice was evaluated both at Kasaragod and Kayangulam centres of the Institute.

At the Kasaragod unit, there was increase of 18% in production of coconut due to this practice. The annual profit per ha increased from Rs. 6023.00 to Rs. 9715.00. The cost-benefit ratio (incremental) during the experimental period worked out at 1.0 : 1.2. The farmer family who maintained the farm and animals could earn about Rs. 250.00 per month.

At Kayangulam, which is a root (wilt) affected area, the increase in nut production was around 28%. The net annual profit from 1 . 3 ha of coconut garden increased from Rs. 1118.00 to Rs. 3613.00. The cost-benefit ratio worked out at 1:1.15. The employment potential increased from 150 man days per ha to 1000 man days due to mixed farming practice.

Root (wilt) disease causes slow but steady decline in productivity of coconut palms. Regular agronomic practices increase the yield of disease affected palms. In the absence of specific control measures for this disease of unknown etiology and non-lethal nature, improvement of agricultural practices to achieve economic returns is of importance. An attempt in this direction by adopting mixed farming, yielded encouraging results. Analyses of soils indicate significant increase of organic carbon, available P, exchangeable Ca and Mg at depths of 0-50 and 50-100 cm. Available K showed significant increase only at 50-100 cm. Slight increase in the nutrient status of the palms was noticed. Evaluation of the microbiological status of the soil under fodder crops revealed comparatively higher values for total bacterial population and the ratio of nitrogen fixing organisms to denitrifiers due to the cultivation of *Stylosanthes gracilis* alone and *S. gracilis* in combination with hybrid napier. Improvement of the soil conditions was reflected on the yield of palms irrespective of their healthy/diseased condition. Although reduction in foliar yellowing of the experimental palms was noticed, the intensity of the disease increased.

BIOCHEMISTRY AND PHYSIOLOGY

Wednesday Forenoon
29–12–1976

1. U Samarajeewa, U Pethyagoda, JD Atputharajah, and NCP Wijeratne, Coconut Research Institute, Lunuwila, Sri Lanka.

2500 words — Fermentation characteristics of some yeast types isolated from coconut toddy.

2. PA Sarangmath, PB Shantappa, BGS Reddy, and DS Kulkarni, Regional Research Station, Mudigere 571 132, Karnataka, India.

2000 words — Varietal differences in nutritive values of copra.

3. RB Nair and AK Sadanandan, Central Plantation Crops Research Institute, Research Centre, Port Blair 744 101, Andamans, India.

1500 words — A comparative study of glucose content of coconut milk in Andamans palms.

4. JA Milburn, Department of Botany, University of Glasgow, Glasgow G12 8QQ, United Kingdom.

3000 words — Vascular physiology of the coconut palm.

5. M Jeganathan, Coconut Research Institute, Lunuwila, Sri Lanka.

2000 words — Limitations in using a specified leaf rank in foliar diagnosis in coconut.

6. KV Kasturi Bai and A Ramadasan, Central Plantation Crops Research Institute, Kasaragod 670 124, Kerala State, India.

2000 words — Changes in the levels of carbohydrates as a function of environmental variables in the hybrid and tall coconut palms.

7. MAT de Silva, Coconut Research Institute, Lunuwila, Sri Lanka.

2000 words — Iron and manganese nutrition of coconut seedlings.

8. R Snehi Dwivedi, PK Ray, and Sunny Ninan, Central Plantation Crops Research Institute, Regional Station, Krishnapuram 690 533, Kerala State, India.

2000 words — Foliar absorption and distribution of radioactive phosphorus in healthy and root (wilt) diseased coconut palms.

9. K Balasubramaniam, Department of Biochemistry, University of Sri Lanka, Kynsey Road, Colombo – 8, Sri Lanka.

2500 words — Biochemical changes during maturation and germination of coconut.

FERMENTATION CHARACTERISTICS OF SOME YEAST TYPES ISOLATED FROM COCONUT TODDY

U. SAMARAJEEWA, U. PETHIYAGODA, J. D. ATPUTHARAJAH, AND N. C. P. WIJERATNE

Coconut Research Institue, Lunuwila, Sri Lanka

Coconut sap (exudate from the unopened inflorescence) is the major base for the liquor industry of Sri Lanka. The sap is allowed to ferment freely in collecting pots under natural conditions and the product is either consumed fresh, bottled and pasteurized, or distilled. The distillate on maturation is called "arrack". The fermentation is brought about by wild yeasts and bacteria leading to products with variable characteristics

It is probable that a high quality liquor with consistent characteristics could be obtained by controlled fermentation of sap using pure yeast cultures. High ambient temperature and the method of collection (tapping) pose special problems in preventing spontaneous fermentation of sap. Traditional methods were employed to suppress fermentation.

This study describes the isolation and identification of micro-organisms associated with fermentation. The pattern of utilization of sugars in the sap and alcohol and acid production during uncontrolled natural fermentation is compared with that of several pure yeast isolates from coconut toddy. Based on the above observations a high alcohol yielding yeast strain has been selected for further study. The quality characteristics of the fermented product, its clarification, and the possibility of adopting controlled fermentation at village technology level will be discussed.

VARIETAL DIFFERENCES IN NUTRITIVE VALUES OF COPRA

P. A. SARANGMATH, P. B. SHANTAPPA, B. G. S. REDDY, AND D. S. KULKARNI

Regional Research Station, Mudigere 571 132, University of Agricultural Sciences, Karnataka, India

Nuts were sampled from the coconut cultivars of Spicata, Gangabondam, Fiji, Kaithali, Laccadive Dwarf, Andaman Dwarf, West Coast Tall, Philippines, S. S. Green, Hybrid, and Kappadam. These were analysed for moisture, protein, phosphorus, potassium, calcium, magnesium, crude fibre, and total mineral contents. Correlation coefficients were worked for various constituents. A high correlation was found between yield of copra and ash content ($r = 0.6982$).

A COMPARATIVE STUDY OF GLUCOSE CONTENT OF COCONUT MILK IN ANDAMANS PALMS

R. B. NAIR AND A. K. SADANANDAN

Central Plantation Crops Research Institute, Research Centre, Port Blair, Andamans 744 101, India

Estimation of glucose content in 6 month old fruits showed significant variation among palms of Tall variety (2 . 40 – 6 . 25; mean 4 . 04%) and not much among the Dwarf palms (3 . 00 - 3 . 60; mean 3 . 34%). Not much of correlation was observed between glucose content and different colour groups (types) in Tall palms. Glucose content was found to increase as the size of the fruits decreased from giant to medium and small to micro, the maximum glucose content being recorded in micro (greenish) fruits. This trait is possibly varietal and hence can be exploited commercially.

VASCULAR PHYSIOLOGY OF THE COCONUT PALM

J. A. MILBURN

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Little is known about the basic physiology of the coconut palm despite its considerable economic importance. As a consequence we are poorly informed when attempting to understand basic requirements of yield and also the course of vascular infections such as the Lethal Yellowing Disease.

The paper describes preliminary experiments on coconut palms growing in Miami, U. S. A. Diurnal relations were studied using both pressure bomb and porometry. Xylem sap pressures were found to vary between - 2 bars by night to around - 12 bars by day. Phloem sap was collected by tapping exudation induced in immature inflorescences by repeated slicing (the traditional technique). Changes in sap concentration and pressure were monitored at different times. It appears that sap concentration is maintained homeostatically to a considerable extent, as in other plants, and is driven through the sieve tubes by pressure. Positive pressures were measured up to about 10 bars. The physiology of other plants will be compared with that of coconut and physiological and pathological implications will be discussed.

LIMITATIONS IN USING A SPECIFIED LEAF RANK IN FOLIAR DIAGNOSIS IN COCONUT

M. JEGANATHAN

Coconut Research Institute, Lunuwila, Sri Lanka

The foliar diagnostic approach to studies on the nutrition of coconut has been employed for at least two decades in various coconut growing countries. The generally accepted sampling leaf has been the 14th since this appeared to be the most sensitive to treatment. Many workers have however found it necessary to look for other leaves as more appropriate to their own particular requirements.

Data from foliar analysis could be used for two purposes, either for *direct diagnostic use* to decide which nutrient or nutrients are causing poor growth or for *predictive use* to decide how much response one could expect from application of fertilisers. It would seem logical therefore that depending on the nature of the problem posed, the method of sampling is also appropriately modified.

Our work has shown that 14th frond may not be the best leaf position for all nutrients. This will be interpreted in terms of work done on magnesium deficiency and sulphur nutrition studies. It has also been seen from a differential irrigation trial that samples taken from a specified leaf rank failed to display consistent trends or results for all elements. Present evidence points out that strict adherence to a specified leaf rank for all nutrient elements is not tenable.

CHANGES IN THE LEVELS OF CARBOHYDRATES AS A FUNCTION OF ENVIRONMENTAL VARIABLES IN THE HYBRID AND TALL COCONUT PALMS

K. V. KASTURI BAI AND A. RAMADASAN

Central Plantation Crops Research Institute, Kasaragod 670 124, Kerala State, India

The productivity of coconut palms has been shown to be influenced by the temperature, sunshine hours and rainfall. A study was, therefore, initiated to investigate the influence of these environmental parameters on carbohydrate fractions in leaves as related to growth in young hybrid and tall coconuts. These studies revealed significant changes in carbohydrate fractions in leaves as related to sunshine hour and rainfall. The results are discussed with special reference to commencement of flowering and productivity in palms.

IRON AND MANGANESE NUTRITION OF COCONUT SEEDLINGS

M. A. T. de SILVA

Coconut Research Institute, Lunuwila, Sri Lanka

The concentration of iron in coconut leaves is generally low. Acidic soil conditions increase the manganese concentration in leaves but do not consistently increase iron concentration.

Two sand culture experiments were conducted to study possible effects of manganese on iron uptake by coconut seedlings. In the first experiment the uptake of iron and manganese from EDTA incorporated nutrient solutions of different reactions were studied. The uptake of both nutrients was high at pH values of 5, 7 and 8, but low at pH values of 4 and 6. These results are discussed in relation to the behaviour of EDTA cation complexes. In the second experiment three levels of Fe and Mn were each supplied at pH 4 and 7. The distribution of manganese in roots and leaf components was largely related to the level of supply. However, iron uptake was affected by pH, but there was no uniformity in the relationship with level of supply.

Determinations of ferrous and ferric iron by an EDTA extraction procedure showed that immobilisation of iron occurs through conversion to the ferric form when the supply of iron was increased. The formation of ferric iron was not related to nutrient pH, but tended to decrease when manganese supply increased. Although evidently the uptake of iron is severely reduced through immobilisation in the roots of coconut seedlings, manganese does not appear to take any part in this process.

FOLIAR ABSORPTION AND DISTRIBUTION OF RADIO ACTIVE PHOSPHORUS IN HEALTHY AND ROOT (WILT) DISEASED COCONUT PALMS

R. SNEHI DWIVEDI, P. K. RAY, AND SUNNY NINAN

Central Plantation Crops Research Institute, Regional Station, Krishnapuram 690 533, Kerala State, India

Radio active 32_P was fed to the coconut leaves in the laboratory and palms in the field. Higher rates of 32_P absorption and accumulation were recorded in healthy palms than in diseased ones at early hours of experiment, but during later period, the trend of 32_P accumulation was reversed. The 32_P activity in the stems of healthy palms was lower than that of diseased ones but a reverse pattern was noted in native phosphorus content. Similarly, the outer, middle, and first fully

opened leaves of healthy palms did not differ much in phosphorus content but in the case of diseased ones wide variations were observed. The autoradiographs and 32_P countings indicated that P was more in the leaves and less in the roots of diseased palms as compared to those of healthy ones.

BIOCHEMICAL CHANGES DURING MATURATION AND GERMINATION OF COCONUT

K. BALASUBRAMANIAM

Department of Biochemistry, University of Sri Lanka, Colombo-8, Sri Lanka

With increasing maturity of coconuts, the reducing sugars of the liquid endosperm decreased with concomitant increases in sucrose content and insoluble polysaccharides of the solid endosperm. The increase in insoluble polysaccharides followed a sigmoid curve. Galactomannans and cellulose but not mannans formed the polysaccharides of very immature kernel. The water soluble galactomannans decreased with maturity, whereas the 4% NaOH–soluble galactomannans reached a maximum value at intermediate stages of maturation and then decreased. The 17% NaOH-soluble galactomannans, mannans, and cellulose increased with maturity and constituted 61%, 26%, and 13% respectively in mature fresh kernel. In mature fresh kernel, a particulate enzyme requiring GDP–mannose is involved in the biosynthesis of mannans. Using α-galactosidase of kernel and β– mannosidase of haustorium, presence of α-linked galactose residues aud β–linked mannose residues was shown in galactomannans and mannans.

During germination of coconut, the reducing and non–reduciug sugars of kernel decreased. In the haustorium, starch increased linearly whereas reducing and non–reducing sugars increased very rapidly and then remained constant. These results suggest that during germination, embryo utilizes stored carbohydrates. The activities of deoxyribonuclease, ribonuclease, 3'–nulceotidase, pyrophosphatase, and acid phosphatase were the same in the kernels of mature, dormant, and germinated nnts. Amylase, β–mannosidase, and sucrase were found only in haustorium. Sucrase activity decreased after an initial rise, whereas activities of amylase and β–mannosidase remained constant.

TECHNOLOGY

Wednesday Forenoon
29–12–1976

1. WH Timmins, Tropical Products Institute, Industrial Development Department, Culham, Nr. Abingdon, United Kingdom.

3000 words — Traditional and modern methods of wet milling fresh coconut kernels.

2. TVP Nambiar, Chemical Construction Company (P) Limited, PB, No. 144, MDLB, North Beach Road, Madras 600 001, Tamil Nadu, India.

3000 words — Maximizing the utility and income from coconuts by the 'Solvol' wet process.

3. AK Goswami, Department of Chemistry, K. R. College, Mathura 281 001, Uttar Pradesh, India.

2000 words — Role of sodium dodecyl sulphate in the stabilization of coconut oil/water emulsions.

4. GN Prabhu, Central Coir Research Institute, Kalavoor, Alleppey 688 001, Kerala State, India.

2500 words — Industrial utilization of coconut husk.

5. JV Bhat, Department of Microbiology, Kasturba Medical College, Manipal 576 119, Karnataka, India.

2500 words — Fibre from coconut fruits.

6. NC Gangi Reddy, T Obi Reddy, D Atchutha Ramayya, G Azeemoddin, and SD Thirumala Rao, Oil Technological Research Institute, Anantapur 575 001, Andhra Pradesh, India.

2000 words — Coconut palm and palm kernel oils — a comparison.

7. M Aslam Ali, Karnataka Carbons Private Ltd., Bangalore 560 041, Karnataka, India.

2000 words — The production of activated carbons from fibre pith.

8. J George, Indian Plywood Industries Research Institute, Tumkur Road, Bangalore 560 022, Karnataka, India.

2000 words — Building materials from coconut husk and its by-products.

TRADITIONAL AND MODERN METHODS OF WET MILLING FRESH COCONUT KERNELS

W. H. TIMMINS

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Research at T P I has largely been directed towards seeking improvements in wet processing methods which would lead to better utilization of the crop within both the traditional and commercial sectors. At all scales of operation an efficient method of size reduction of the fresh kernel is essential if maximum recovery of oil is to be subsequently achieved.

Traditionally the kernel is grated prior to pressing. However, the methods and tools used for the grating operation differ considerably from one culture to another. The paper reports the findings of a world-wide review carried out on the methods and tools used in the traditional sector. Information arising from this study has been utilised to develop new grating devices. These simple devices are inexpensive, robust, and have efficient grating characteristics. It is considered that adoption of these novel graters would tend to reduce overall domestic consumption of fresh coconuts, thereby increasing export potential.

Modern wet processes also differ in the methods and equipment used for size reduction of the fresh kernel. The paper reviews some of the wet-milling systems developed, and in addition, summarises results of fundamental studies carried out on the wet-milling operation. Mill selection criteria are discussed and the T P I wet-milling system described.

MAXIMISING THE UTILITY AND INCOME FROM COCONUTS BY THE 'SOLVOL' WET PROCESS

T. V. P. NAMBIAR

Chemical Construction Company, North Beach Road, Madras 600 001, Tamil Nadu, India

In recent years a significant break-through in coconut technology has been achieved by the 'SOLVOL' process (Chemical Construction Co (P) Ltd., of India) which may briefly be described as under :

Soon after harvesting and bringing to the processing plant, coconuts are dehusked, split, and deshelled to recover the kernel. The outer brown cover (testa) is removed and after sterilization, the kernel is shredded into a fine meal and squeezed in continuous presses to obtain the milk. The milk is spray-dried under high vacuum and the resulting oil-cum-protein slurry is centrifuged or filtered to separate the oil from the "proteins". The proteins are solvent-extracted, (using an edible grade solvent) to remove and recover the oil adhering to it. The squeezed

meal and testa are also dried and solvent extracted to remove and recover the oil. The oil recovered by solvent extraction is fully refined before marketing.

Coconut water (endosperm water) is collected while splitting and filtered and dried under high vacuum to produce coconut honey. The coconut shell and husk are also processed further for recovery of coir fibre, coconut shell carbon, shell chemicals, and cooking gas on destructive distillation.

The 'SOLVOL' process is a completely integrated process utilizing every part of the coconut for deriving maximum benefits.

ROLE OF SODIUM DODECYL SULPHATE IN THE STABILIZATION OF COCONUT OIL / WATER EMULSIONS

A. K. GOSWAMI

Department of Chemistry, K. R. College, Mathura 281 001, Uttar Pradesh, India

The role of sodium dodecyl sulphate (S D S) in the stability of coconut oil in water emulsion was studied. Flocculation studies were made haemocytometrically in the presence of varying concentrations of different electrolytes, viz, sodium nitrate, barium nitrate, lead nitrate, chromium nitrate, aluminium nitrate, and thorium nitrate. Zeta potentials were calculated from the mobility data obtained micro-electrophoretically in the presence of electrolytes. With the help of these data the stability of the system has been discussed in the light of D L V O theory. The greater stability of the coconut oil / water emulsion is the basis of many cosmetic emulsions.

INDUSTRIAL UTILIZATION OF COCONUT HUSK

G. N. PRABHU

Central Coir Research Institute, Kalavoor 688 522, Kerala State, India

Industrial utilization of coconut husk has so far been confined to extraction of coir of different grades which are preferred for manufacture of coir products of different types. Coir extracted from green husks termed "white/retted fibre" is used in the preparation of yarn, cordage and a wide range of floor furnishing materials such as foot mats, mattings, rugs, carpets, and speciality articles such as filters etc. "Brown fibre" or coir extracted from dry/semi-dry husks is used in the manufacture of brushes, curled coir, for filling upholstery, and various types of rubberised coir products which serve as bed mattresses, cushioning blocks, air filters, and packaging materials. Presenting data on the country-wise output of coconuts and production of coir, the extent of untapped potential is projected. Reviewing the methods in coir extraction and further processing of the fibre into yarn and different types of products, the technological improvements contributed

to higher productivity entailing reduced physical strain on the part of the operatives in fibre extraction, spinning and weaving, are described. The techniques evolved for improving the feel, texture and appeal of coir by softening, bleaching, dyeing, and finishing treatments have also been dealt with in brief. Elucidating the results arising out of the studies in new uses of coir with particular reference to use of coir panels for improving interior foam acoustics and thermal insulation of buildings, coir mattings for erosion control of soil slopes of highways and railway embankments, coir mattings as a barricading material for sand stowing operations in mines and coir-reinforced partition panels and roofing boards in building construction, the need to further use of coir in these new areas of application is stressed for progressive industrial utilization of the material.

THE FIBRE FROM COCONUT FRUITS

J. V. BHAT

ICAR Project Laboratory,
Kasturba Medical College, Manipal 576 119, Karnataka, India

The fibre from the thick fibrous mesocarp of the fruits of coconut palm, known the world over as coir, has been pointed out to be a versatile material which enters the world market as coir fibre, spun yarn, rope, woven mats, mattings, rugs and carpets, brooms and brushes, and also other rubberized products. Its method of extraction in India has been shown to be through the retting (fermentation) of husks, a process unique in that it takes place in brine and requires several weeks to get completed and in which a wide variety of microorganisms participate. The reason for the long period required for retting has been explained as due to the presence in the husk of considerable quantities of phenolics which have to be leached and / or decomposed away by microbial activities before the fibre releasing organisms can attack pectic substances. The two microbiological processes-polyphenolics degradation and breakdown of pectic substance have been observed to run parallel and take not less than four months to complete even under ideal conditions unlike the retting of other plant fibres which need only few days to get complete.

The microorganisms associated with retting have been demonstrated to be predomenant gram negative short rods and yeasts. The genera observed to decompose pectic substances have been identified as those belonging to the genera *Achromobacter, Alcaligenes, Aerobacter, Escherichia, Pseudomonas, Paracolobactrum, Micrococcus* and *Bacillus.* Yeast species of *Candida, Cryptococcus,* and *Rhodotorula* have also been reported to possess the ability to attack pectic substances. The successive pattern of microflora in the rets has been followed. *Debaryomyces hansenii,* a yeast, has been proved to be powerful species in its ability to degrade phenolics. The *Micrococcus* species isolated likewise has been proved to be equally

efficient and capable of even forming 3, 4, 3' 4' tetradihydroxy diphenyl from catechol.

Several factors influencing retting have been detailed aud salt has been proved to be not essential in the process. Pre-crushing of husks before steeping them in water, aeration, and flushing of ret liquor have been shown to hasten retting. The possibility of reducing retting period by use of cultures and improving the quality of fibre have been suggested.

COCONUT PALM AND PALM KERNEL OILS — A COMPARISON

N. C. GANGI REDDY, T. OBI REDDY, D. ATCHUTHA RAMAYYA, G. AZEEMODDIN, AND S. D. THIRUMALA RAO

Oil Technological Research Institute, Anantapur 515 001, Andhra Pradesh, India

Fats from palms are important not only in terms of total quantity produced but also because they differ in composition from animal fats originating in colder climates. This is especially true of fats from the seed kernels, e. g., coconut oil and palm kernel oil, whose composition makes them better suited to serve some important uses than other fats. In the present paper, a comparison of important characteristics and standards of coconut oil, palm oil, and palm kernel oil in different countries is presented. In view of the varied uses of latter oils and their probable commercial availability in future in this country, it has become necessary to lay down standards for these oils. Palm oil is used both as a cooking fat and as an industrial oil. Palm kernel oil is the nearest substitute to coconut oil with which the former is compared.

THE PRODUCTION OF ACTIVATED CARBONS FROM FIBRE PITH

M. ASLAM ALI

Karnataka Carbons Private Ltd., Bangalore 560 041, India

The technological feasibility of the production of Activated Carbons from coir fibre pith obtained from coir factories, is discussed. The surface areas and adsorptive capacities of different samples are studied. The mechanical strength is also studied with a view to exploit the product commercially. Necessary data relating to commercial production and utilization of coir fibre pith is given. Methods by which the adsorptive capacities could be increased, are also discussed in detail.

BUILDING MATERIALS FROM COCONUT HUSK AND ITS BY-PRODUCTS

J. GEORGE

Indian Plywood Industries Research Institute, Tumkur Road, Bangalore 560 022, Karnataka, India

(Abstract not received)

BASIC STUDIES

Wednesday Afternoon
29–12–1976

1. I Henry Louis and K Balasubramanian, Tamil Nadu Agricultural University, Subcentre, Veppankulam 641 906, Tamil Nadu, India.

2000 words — Development of root system in the coconut.

2. NM Nayar, Central Plantation Crops Research Institute, Regional Station, Vittal 574 243, Karnataka, India.

2500 words — Origin of coconut *(Cocos nucifera L)*.

3. TA Davis, Indian Statistical Institute, Calcutta 700 034, West Bengal, India.

2500 words — Association of coconut foliar asymmetry with latitude.

4. VP Potty and NP Jayasankar, Central Plantation Crops Research Institute, Regional Station, Krishnapuram 690 533, Kerala State, India.

2000 words — Influence of crop mixing of hybrid napier on the root zone microflora of coconut palm.

5. WW Schwabe, Department of Horticulture, Wye College, Kent, United Kingdom.

2500 words — Attempts at vegetative propagation of coconut palm.

6. RB Nair, Central Plantation Crops Research Institute, Research Centre, Port Blair 744 101, Andamans, India.

1500 words — A coconut palm producing Pigmy-sized barren fruits.

7. EV de Guzman, AG Rafols, and AG del Rosario, Department of Horticulture, University of the Philippines, Los Banos, College Laguna, The Philippines.

2500 words — Preliminary observation on the floral biology and fruiting of *in vitro* coconut trees.

DEVELOPMENT OF ROOT SYSTEMS IN THE COCONUT

I. HENRY LOUIS AND K. BALASUBRAMANIAN

Tamil Nadu Agricultural University, Sub centre, Veppankulam 614 906
Tamil Nadu, India

The rooting pattern of eight year old palms was studied under eight different combinations of manure, irrigation, and cultural operations. Manuring increased the production of primary roots 592.0 per cent over control. Both manuring and irrigation increased the length of the roots and percentage of horizontal roots. In palms receiving manure and irrigation, the root zone area increased by 40 and 50 per cent. In individual palms under manurial treatment the bole expanded up to 60 cm. Cultural operations suppressed the upward elongation of the root zone. Increase in surface area of the root zone was due to the upward elongation and not due to the sideway widening of the existing bole. For every 1.7 sq. cm. area on the bole surface one root was found occupying an area of 0.8 to 1.0 sq. cm. Control palms had a tendency to produce more water roots than treated palms. Oblique roots penetrated to a distance of 2.0 – 2.5 meters from the stem. Maximum number of secondary roots per unit length was recorded in palms with no manure or cultural operations. Respiratory roots concentrated more in the first two meters of the primary and secondary roots of the treated palms as compared to the control.

ORIGIN OF COCONUT *(COCOS NUCIFERA L.)*

N. M. NAYAR

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Vittal 574 243, Karnataka, India

The literature relating to the place, time, and mode of evolution of the coconut palm is reviewed. These data are then examined in the light of the present concepts on the origin of cultivated plants. These include evaluation of the available information on the distribution, phytogeography, cytogenetics, paleobotany, embryology, and anatomy of the species. It is proposed that coconut *(Cocos nucifera L.)* may have been brought into use by man only in recent times in comparison to the other domesticated plants and that there is no need to assume about the occurrence of a truly wild coconut palm either now or in the immediate past. Just as with many other tropical plants used by man, coconut palm of today may not really have undergone much evolutionary changes as a result of deliberate cultivation by man. It is, however, necessary to carry out a thorough exploration of the Tropical American forests particularly and also the Melanesian and Far Eastern regions for the presence of naturally occurring and less evolved forms of coconut.

ASSOCIATION OF COCONUT FOLIAR ASYMMETRY WITH LATITUDE

T. ANTONY DAVIS

Bioscience Department, Indian Statistical Institute, Calcutta 700 035, West Bengal, India

The phyllotaxy of the coconut is alternate, and so the younger of any two consecutive leaves will be nearer to the older leaf either by its left side or its right. In the former case, the leaves will form a single left-handed (clockwise) spiral, and in the latter case into one right-handed (counter-clockwise) spiral. Since any two consecutive leaves subtend an angle roughly approximating to the Fibonacci angle (137°), the coconut crown displays five clearly visible spirals. The direction of the five spirals in a crown where the single spiral (formed by consecutive leaves) is clockwise will be counter-clockwise, and clockwise, where the single spiral moves counter-clockwise.

The spirality of 52960 coconut palms was recorded from 38 countries/regions in both the hemispheres, out of which 51.16% were left-spiralled. The observations were split into those for the northern hemisphere and those for southern hemisphere. The data were statistically analysed to see whether the foliar asymmetry associates with the latitude. Positive results were obtained.

INFLUENCE OF CROP MIXING OF HYBRID NAPIER ON THE ROOT ZONE MICROFLORA OF COCONUT PALM

V. P. POTTY AND N. P. JAYASANKAR

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Inter-cropping of the fodder grass hybrid napier with coconut palm resulted in the proliferation of total bacteria and nitrogen fixing organisms in the coconut rhizosphere irrespective of the condition of the palm. Crop mixing enhanced phosphate solubilizing bacteria in the root region of the coconut palm with root (wilt) affected palms harbouring significantly higher numbers. The trend was however reversed on application of inorganic manures particularly phosphatic fertilisers There was a decrease in the nitrogen fixing and phosphate solubi izing microflora in the soil adhering to the coconut roots. The difference between the experimental and control plots was also not significant.

ATTEMPTS AT VEGETATIVE PROPAGATION OF COCONUT PALM

W. W. SCHWABE

Department of Horticulture, Wye College, Kent, United Kingdom

Experiments have been carried out to obtain vegetative propagation of coconut palm from explants of variety of tissues including apical meristem tissue, leaf, inflorescence, and root tissue. A mineral salt medium has been defined specifically suitable for coconut and perhaps other palm tissue and the organic constituents have been optimized maximum callus growth. Experiments with callus tissue and organized inflorescence explants will be described. Brief mention will also be made of experiments to obtain branching in intact palms.

A COCONUT PALM PRODUCING PIGMY - SIZED BARREN FRUITS

R. B. NAIR

Central Plantation Crops Research Institute, Research Centre, Port Blair 744 101, Andamans, India

Production of barren fruits in coconut is a common feature in all coconut tracts. The barrenness may be partial to complete and is estimated to be about three per cent of the yield. However, the occurrence of sterile palms is a rare phenomenon. One palm in Car Nicobar Island was found to produce sterile male and female flowers with no button shedding. The pigmy sized barren fruits attained a maximum size of 9 c m × 5 c m, and a volume of 115 c c after 12 months of growth. All the fruits possessed two internal supernumerary whorls of three alternating carpels each and the embryo sac was under-developed. The male flowers also had three whorls of alternating supernumerary boat-like fleshy sepals, the anthers dehisced normally but were mostly devoid of pollen.

PRELIMINARY OBSERVATIONS ON THE FLORAL BIOLOGY AND FRUITING OF *IN VITRO* COCONUT TREES

E. V. DE GUZMAN, A. G. RAFOLS AND A. G. del ROSARIO

Department of Horticulture, University of the Philippines, Los Banos, College, Laguna, The Philippines

Fifteen trees, 13 makapuno and 2 non-makapuno, which were propagated by embryo culture constitute the experimental plants. Regular observations were made on some aspects floral biology since the commencement of flowering which occurred 39 to 62 months after transplanting to the ground. The flowering age (from embryo) of the plants varied from 68 to 95 months.

Flowering habits and floral structure in both types of *in vitro* plants were comparable to those described for the species especially the Tall variety. However, both types exhibited intra-and inter-inflorescence overlapping of the male and female phases. In makapuno the average duration was 2.17 days for the intra-overlap and 0.95 days for the inter-overlap. The corresponding values are 0.30 and 1.65 days respectively for the non-makapuno.

Within the first 19 months of flowering the first tree to become reproductive has already produced 30 inflorescences. Pollen viability was high; fruit setting per bunch varies from 5 – 80%. Seventy four nuts have been harvested within 8 months and based on the 58 (excluding one barren) actually opened the yield of makapuno was 84%. From one non-makapuno tree all the 4 nuts harvested were non-makapuno.

The observations show that the makapuno embryo is capable of completing its life cycle provided the initial problem of non-germination is overcome. Despite the initial growth lag the total duration of the vegetative phase was not overly prolonged by the *in vitro* method of propagation. The observed yield of makapuno nuts tends to favour the hypothesis that the tree propagated from the makapuno nut is potentially pure-makapuno bearing. Further observations will be made to determine if the duration of the intra-spadix overlap can be used to differentiate the makapuno from the non-makapuno.

DISEASES

Thursday Forenoon
30 – 12 – 1976

1. HC Govindu, ANS Rao, KV Keshava Murthy and, CG Shaw, Department of Plant Pathology, University of Agricultural Sciences, Bangalore 560 024, Karnataka, India.

2500 words — Biology of *Ganoderma lucidum* (Leys) Karst and control of *anabe roga* of coconut.

2. K Radha and Thomas Joseph, Central Plantation Crops Research Institute, Regional Station, Krishnapuram 690 533, Kerala State, India.

2500 words — Bud rot disease of coconut : A reappraisal of associated factors.

3. GP Blair, Red Ring Research Division, Central Experiment Station, Centeno, Trinidad.

3000 words — Red ring disease of the coconut palm.

4. K Mathen, N Gopinathan Pillai, and K Radha, Central Plantation Crops Research Institute, Regional Station, Krishnapuram 690 533, Kerala State, India.

2500 words — A terminology for the coconut root (wilt) disease.

BIOLOGY OF *GANODERMA LUCIDUM* (LEYS) KARST. AND CONTROL OF *ANABE ROGA* OF COCONUT

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Ganoderma lucidum (Leys) Karst. causes *anabe roga* (mushroom disease) in Karnataka State. It is widely present in the *maidan* parts especially in sandy soils of the southern region of the state. This disease seems to affect older palms of neglected gardens more than the young palms. The pathogen has a wide host range. Some of the important hosts are *Areca catechu, Mangifera indica, Artocarpus integrifolia, Cassia siamea, Pongamia glabra, Delbergia sissoo, Morus alba, Acasia* sp., *Delonix regia, Citrus* sp. (esp., acid lime), etc.

The disease manifests itself in various forms presenting different symptoms at various stages of growth of the coconut palm. The three characteristic symptoms expressed are: On the crown the outer whorl of leaves droop down, become yellowish and reduced in size, and ultimately dry up. The stem shows characteristic oozing of brownish gummy substance through cracks and wounds on the lower parts. Late in disease symptomatology, fructifications occur in the form of corky brackets of the pore fungus at the lower part of the trunk. The ultimate result is death of the palm.

The seat of infection is the base of trunk and roots. Affected roots are discoloured, dry, and brittle. The interior of the affected stem becomes dark brown 50–75 cm from the base and emit a musty smell. The fungus affects xylem vessels and xylem parenchyma only and not phloem. Affected vessels show tyloses.

The *anabe roga* in coconut is controlled by biological, cultural and chemical methods. In recent years, several fungicides including some systemics and antibiotics have been tried. The present studies include the results of research with a new coded antibiotic which gave good control at a concentration of 7.5 g/10 l water when applied at the basal portion of the palm through a bore.

BUD ROT DISEASE OF COCONUT – A REAPPRAISAL OF ASSOCIATED FACTORS

K. RADHA AND THOMAS JOSEPH

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Bud rot disease of coconut caused by *Phytophthora palmivora* Butl. often tends to be fatal. A critical examination of the environmental factors associated with the disease revealed that none of them is solely responsible for its deve-

lopment. Manifestation of the disease requires a set of favourable factors of which high relative humidity and low temperature are more important. Extent of "favourable days" determined the incidence and severity of the disease, which in turn was dependant on the monsoon rains. Palms aged 3 – 20 years under suitable microclimate are the most susceptible.

The role of *Phytophthora palmivora* in the incidence of the disease, the nature of damage and the possible implication of secondary invaders such as bacteria in aggravating symptoms have been assessed.

RED RING DISEASE OF THE COCONUT PALM

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Red ring disease of coconut palm is incited by the nematode, *Rhadinaphelenchus cocophilus,* which enters trees through cracks in the stems near leaf bases. It then moves downward and simultaneously around the stem in the sub-peripheral region to which it is attracted by the high CO_2 content of that area.

Eggs, larvae, and adults are then found throughout the invaded tissue; and with a life cycle of only 9 days, the nematode produces two generations before the reddened tissue, the main internal symptom, is fully developed 25 days after inoculation.

The first external symptom, yellowing of leaves, becomes visible 35 days after inoculation, by which time, xylem vessels in the discoloured zone are occluded by tyloses thereby impeding water movement and the dependant exhaustion of CO_2, which in healthy trees, is transported in the transpiration stream *via*, xylem vessels to leaves.

CO_2 then builds up to concentrations which prolong the life of larvae, but prevent them from maturing or migrating inwards and eventually induce anabiosis. Adults and eggs are then found only at the upper extremity, while larvae only are found throughout the rest of the discoloured zone in the stem.

The disease is fatal and control was attempted by injecting poison into stems and spraying crowns with insecticides. Bitumen has been tried as a mechanical barrier in leaf axils, and complete control has been achieved in field plots by placing a granular nematocidal preparation in leaf axils.

A TERMINOLOGY FOR THE COCONUT ROOT (WILT) DISEASE

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Coconut root (wilt) disease has been referred to by various authors under different names. The variations in the name have created confusion among readers and reviewers to mistake the disease for other disorders in the palm. A list of all such names used in the literature hitherto is given in alphabetical order. A chronological order of the variations is cited. Suitability of each name is discussed. From among the available names, coconut root (wilt) disease is chosen and recommended for use by all workers for the sake of uniformity, until such time as a new name can justifiably replace it.

PESTS

Thursday Forenoon
30–12–1976

1. L Nadarajan and GP Channa Basavanna, Department of Entomology, University of Agricultural Sciences, Bangalore 560 024, Karnataka, India.

2000 words — Studies on integrated control of coconut black headed caterpillar *Nephantis serinopa* Meyrick (Lepidoptera, Cryptophasidae).

2. PR Dharmadhikari, PACR Perera, TMF Hassen, and SV Sinnatamby, FAO/UNDP Project, Coconut Research Institute, Lunuwila, Sri Lanka.

2000 words — The introduction of predators for the control of the coconut scale *Aspidiotus destructor* Sign. in Sri Lanka.

3. Chandy Kurian, GB Pillai, J Antony, VA Abraham, and P Natarajan, Central Plantation Crops Research Institute, Regional Station, Krishnapuram 690 533, Kerala State, India.

2500 words — Biological control of insect pests of Coconut : A review.

4. P Kanagaratnam, Coconut Research Institute, Lunuwila, Sri Lanka.

2500 words — New developments in the control of pests and weeds of coconuts in Sri Lanka.

5. GK Veeresh, Department of Entomology, University of Agricultural Sciences, Hebbal, Bangalore 560 024, Karnataka India.

2000 words — Coconut root grubs and their control in Karnataka.

6. D Mariau, Institut de Recherches Huiles et Oleagineux, 11 Square Petrarque, 75016 Paris, France.

2000 words — *Aceria (Eriophyes) guerreronis* : an important pest of African and American coconut groves.

7. BK Guruprasad and K Srihari, Department of Vertebrate Biology, University of Agricultural Sciences, GKVK Campus, Bangalore 562 142, Karnataka, India.

2000 words — Rodent damage and its control in coconut groves.

STUDIES ON INTEGRATED CONTROL OF COCONUT BLACK HEADED CATERPILLAR *NEPHANTIS SERINOPA* MEYRICK (LEPIDOPTERA: CRYPTOPHASIDAE)

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Investigations were conducted for integrating the existing parasite release for controlling *Nephantis serinopa*, with new approach like steri'e male release and stem injection of systemic insecticides. Fumigation of adult males with chemosterilants, thiotepa at 100 mg and hempa at 1 ml for 3 hr at 30 C produced sterility of 100 and 89% respectively. Irradiation and adult emergence were not satisfactory. When pupae were irradiated with 40 krads one day prior to adult emergence, 80% sterility and 0% hatchability were noticed. Stem injection of a systemic insecticide monocrotophos at 7 ml per palm was found to be effective with 90 to 100% mortality of larvae in trees of 9 to 10 years age, and 60 to 70% mortality in taller trees about 50 years old.

THE INTRODUCTION OF PREDATORS FOR THE CONTROL OF THE COCONUT SCALE *ASPIDIOTUS DESTRUCTOR* SIGN. IN SRI LANKA

P. R. DHARMADHIKARI, P. A. C. R. PERERA, T. M. F. HASSEN, AND S. V. SINNATAMBY

FAO/UNDP Project, Coconut Research Institute, Lunuwila, Sri Lanka

The coconut scale *Aspidiotus destructor* is a moderately serious pest of coconut in Sri Lanka. It is normally kept in check by the two prevailing monsoons and an indigenous Coccinellid predator *Chilochorus nigritus* L. Recent outbreaks of the pest, however, prompted the search for more effective methods of controlling the pest. Coconut scale occurs throughout the coconut growing areas of the island but is more pronounced under conditions producing luxurient growth with thick intermingling foliage. Four predators of which *C. nigritus* predominates and a parasite *Aphytes* sp. have been recorded.

Cryptognatha nodiceps Mshl., *Lindorus lophantae* L., *Azya trinitatis* Mshl. *Chilochorus cacti* Mshl. and *Coccidiphilus* sp. were recently introduced into Sri Lanka in attempts at controlling the pest. The predators were mass-multiplied in the laboratory on coconut scale bred on pumpkins for subsequent mass-releases in affected areas. Approximately 30,000 predators have been released initially at 18 localities spread over 3 major provinces. No recoveries have so far been recorded.

BIOLOGICAL CONTROL OF INSECT PESTS OF COCONUT - A REVIEW

CHANDY KURIAN, G. B. PILLAI, J. ANTONY, V. A. ABRAHAM, AND P. NATARAJAN

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Oryctes rhinoceros L., *Nephantis serinopa* M., *Rhynchophorus ferrugineus* F., and *Leucopholis coneophora* B. are the major pests of coconut in India. These insects are attacked by a number of parasites, predators, and microorganisms including nematodes. The most important biological control agents for the control of the black beetle are the indigenous predators *Santalus parallelus* P., *Agrypnus* (near *bifoveatus* C.), and the exotic reduviid bug *Platymeris laevicollis* G. The pathogens *Metarrhizium anisopliae* (M.) S., *Rhabdionvirus oryctes* and a nematode *Neoaplectana carpocapsae* D. (DD - 136) also show promise. The establishment of the above agents depends very much on the ecological conditions and biotic factors.

No biological agent other than *Chelisoches moris* F. has been reported on red palm weevil in India. The scope of utilizing parasites, predators, and pathogens for the control of the cockchafer is also discussed. The leaf eating slug caterpillars *Contheyla rotunda* H., *Macroplectra nararia* M., and *Parasa lepida* C. are attacked by bacterial, fungal and insect parasites. *Stephanitis typicus* D. the suspected vector of the root (wilt) disease of coconut has a predator in *Stethoconus praefectus* D.

Mention is made also of parasites obtained on these pests in other countries. A few such examples of *Aspidiotus destructor* S. (found in India as well), *Artona catoscantha* H., *Levuana irridiscens* B - B, and *Promecotheca reichii* B. are given. Some of the main problems encountered in their utilization are also pointed out.

NEW DEVELOPMENTS IN THE CONTROL OF PESTS AND WEEDS OF COCONUT IN SRI LANKA

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The management and control of pests and weeds of coconut in Sri Lanka have sought to exploit a variety of methods. These include field sanitation, trapping, the use of parasites, predators, bacterial and viral pathogens and conventional chemical methods. Outstanding success has been achieved in the control of *Promecotheca cumingi* while at the other extreme, two decades of sustained mass releases of parasites have failed to bring *Nephantis serinopa* under effective control. While the indigenous predator *Chilocorus nigritus* appears to be an effective agent for the control of *Aspidiotus destructor,* several exotic predators have failed to

establish. The paper will attempt to examine some of the special factors that may have determined the success or failure of attempted control measures.

The more recent approaches and the results of preliminary investigations on the use of bacterial and viral pathogens and systemic insecticides for the control of selected pests and of the leaf eating caterpillar *Ammalo insulata* for the management of *Eupatorium odoratum* will be presented and discussed.

COCONUT ROOT GRUBS AND THEIR CONTROL IN KARNATAKA

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Three species of white grubs severely damage coconut in Karnataka. While *Leucopholis coneophora* Burmeister, and *Leucopholis coneophora* Blanchard, are confined to heavy rainfall areas of coastal Karnataka and Malnad tract, *Holotrichia serrata* Fabricius, is found in the plains only.

Bioecology of *Holotrichia serrata* has been studied. Since the adults emerge during particular hours after the first summer rains, and have a decided performance to certain host plants, adult collection was found to be an effective means of control of this species. Several alternate methods have been developed to manage root grubs in cultivated fields. However, chemical method was found to be more practicable for the control of grubs in coconut gardens. The time and method of application decide the efficacy of effective insecticides. Some of the new phosphatic and carbamate granular and liquid formulations, including phorate 10 G, counter 5 G, carbofuran 3 G, Dursban 200 EC, have given significant results but without much residual action. Application of chemicals uniformly all over the affected area 3–4 weeks after the summer rains when the grubs are confined to the upper 8–10 cm soil has given complete control of grubs. A fungal parasite *Beauveria brongniartii* (Sacc.) reported for the first time from India has shown promise of bringing down the population of the pest.

ACERIA (ERIOPHYES) GUERRERONIS: AN IMPORTANT PEST OF AFRICAN AND AMERICAN COCONUT GROVES

D. MARIAU

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Aceria guerreronis which does not exceed 250 microns in length, lives within the shelter of the floral parts of the coconuts during the first month following pollination. In destroying the young tissues, the mite prevents the nut from deve-

loping normally, leading to a decrease in copra which can reach upto 25% and a generally reduced fruit fall. The different varieties of coconut palm do not react in the same way to the attacks, the Yellow Dwarf being more sensitive than the West African Tall and the Cambodia variety being seldom attacked. Chemical methods have proved effective, as for instance with cyhexatin, chinomethionate, and monocrotophos. The application of monocrotophos at 0 . 04%, reduced losses by 90%. But these treatments should be given very frequently (6 treatments per year), and hence it cannot be recommended. The development of more economical control methods, has been considered. In this, the points to be considered are : utilization of potential mite diseases which could be identified in the natural state, control with predatory mites, and application of specific planting methods.

RODENT DAMAGE AND ITS CONTROL IN COCONUT GROVES

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A comprehensive review of the literature is given relating to the species of rodents attacking coconuts, their relative occurrence in the different regions of the world, the extent of damage caused by them, and the control measures adopted the world over. The nature and extent of damage caused by rodents is compared with the damage caused by the important pests and diseases of coconut. It is proposed that the rodents are the single most important pest affecting coconuts.

The work relating to the damage caused by rodents in the Regional Research Station, Arsikere is reviewed along with the various measures adopted for their control. The relative efficacies of the various methods of control are discussed.

DISEASES OF UNCERTAIN ETIOLOGY

Thursday Afternoon
30–12–1976

1. JJ Solomon, M Sasikala, and P Shanta, Central Plantation Crops Research Institute, Regional Station, Krishnapuram 690 533, Kerala State, India.

2000 words — A serological test for the detection of the root (wilt) disease of coconut.

2. J Giannotti and M Dollet, Station de Recherches Cytopathologiques, INRA, 30380 St. Christol les Ales, France.

2500 words — Coconut yellow disease of West Africa.

3. JW Randles, Erlinda P Rillo, and G Boocardo, Department of Plant Pathology, Waite Agricultural Research Institute, University of Adelaide, Glen Osmond 5064, Australia.

2500 words — The association of anomalous RNA with Cadang-Cadang disease of coconut and evidence for a viroid etiology.

4. JH Tsai, University of Florida, Agricultural Research Centre, 3205, SW 70 Avenue, Fort Lauderdale, Fla., 33314, United States of America.

2000 words — Attempt to transmit lethal yellowing of coconut palms by suspected vectors.

5. MP Govindankutty and K Vellaichamy, Central Plantation Crops Research Institute, Regional Station, Krishnapuram 690 533, Kerala State, India.

2000 words — Histopathology of the roots of coconut palm affected with root (wilt) disease.

6. JL Renard, D Marius, JP Morin, and G Quillec, Institut de Recherches pour les Huiles et Oleagineux, Plantation Robert Michaux, BP 8 Dabou, Ivory Coast.

2000 words — Two new coconut palm diseases in the nursery and on young plantations in Ivory Coast.

7. T Jaganathan, KM Vijayan, KT Subba Raja, and R Ramasami, Coconut Root (wilt) Disease Scheme, Muthupet 614 704, Tamil Nadu, India.

2000 words — Investigations on Thanjavur wilt disease of coconut in Tamil Nadu, India.

8. K Maramorosch, Waksman Institute of Microbiology, Rutgers University, New Brunswick, NJ., 08903 United States of America.

2500 words — Uncertain etiology diseases of coconut palm.

9. MV Parthasarathy, Section of Genetics, Development and Physiology, Cornell University, Ithaca, NY., 14853, United States of America.

2500 words — Hart rot — a coconut disease of Suriname associated with a trypanosomatid flagellate.

10. Randolph E McCoy, University of Florida, Agricultural Research Centre, Fort Lauderldale, Fla. 33314, United States of America.

2500 words — Use of oxytetracycline for prophylactic and therapeutic treatment for lethal yellowing in Florida.

A SEROLOGICAL TEST FOR THE DETECTION OF THE ROOT (WILT) DISEASE OF COCONUT

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Hitherto the root (wilt) disease of coconut has been diagnosed only on the basis of visual symptoms with flaccidity of leaves as the primary symptom. A serological test for quick and early detection of the disease has been evolved. Samples drawn from healthy and diseased palms of varying intensities and growing in different soil types were tested with the root (wilt) antiserum by cross absorption technique. All the 70 healthy samples from various parts of India gave negative reaction while 158 out of 161 diseased samples gave positive reaction. The 21 of the 60 apparently healthy samples (with no visual symptoms) tested, which gave positive reaction, are being observed for the development of symptoms to assess the sensitivity and diagnostic value of this test.

COCONUT YELLOW DISEASE OF WEST AFRICA

J. GIANNOTTI AND MICHEL DOLLET

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In West Africa coconut plantations are found along the coast of the Gulf of Guinea in the coastal areas of Cameroon, Togo, and Ghana. Trees show withering with yellowing, nut dropping, flower abortions, and death of palms. These diseases are locally known as Kribi, Abwa, Cap St. Paul, and Kaincope. Kaincope disease was reported from Togo as early as 1932. Since then around the original focus at one end, another new focus has appeared along the coast upto at least 50 km and the disease is spreading slowly in patches. Since 1952 the hypothesis of a contageous disease has been put forward and it is from this angle that the study of the etiology of the disease has developed.

With cytochemical techniques it has been seen that the phloem cells of diseased plants contain a lightly dense material. This material is often found in the vicinity of the pores. Roots and inflorescence of the same palm were used for *in vitro* culture studies for mycoplasma.

EM studies of the inflorescence of a palm showing the first symptoms of the disease showed mycoplasma-like organisms containing ribosomes and DNA strands. However, their quantities have been relatively low in tissues which have been examined until now. Studies are now being carried out on several aspects : search for plant tissues supporting actively the multiplication of mycoplasma, and trying to extend the observations to other known coconut yellow diseases of Africa.

THE ASSOCIATION OF ANOMALOUS RNA WITH CADANG-CADANG DISEASE OF COCONUT AND EVIDENCE FOR A VIROID ETIOLOGY

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Cadang-cadang disease of coconut is a disease of unknown etiology, first described as serious in the Philippines in 1931, and apparently still confined to that country. Symptoms and epidemiology are not inconsistent with a virus etiology, but no viral pathogen has been found to be associated with the disease.

A search for unusual nucleic acids in diseased palms led to the discovery of two low molecular weight RNA species (ccRNA-1, ca. 80,000d; ccRNA-2, ca. 200, 000d) which were too small to have originated from virus particles. Studies of the properties of ccRNA-1 indicate that it is structurally similar to two of the known viroids (low molecular weight, uncoated RNA pathogens) potato spindle tuber and citrus exocortis viroids, and dissimilar from normal plant RNA. Inoculation of coconut seedlings with a combined unfractionated nucleic acid extract from diseased palms led to the appearance of ccRNA-1 and-2 in 60% of the inoculated seedlings. The transmissibility of the disease associated RNA's, and the size and structure of ccRNA-1 supports a viroid hypothesis for cadang-cadang, but final proof will depend upon demonstrating the pathogenicity of one or other of the isolated RNA's. Failure of tetracycline or penicillin injections to affect either the progress of the disease or the detection of ccRNA-1 and-2 in diseased palms indicate that mycoplasma-like-organisms have no role in cadang-cadang disease.

ATTEMPT TO TRANSMIT LETHAL YELLOWING OF COCONUT PALMS BY SUSPECTED VECTORS

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Three approaches which have been used in lethal yellowing transmission studies are: (1) toxins which may be induced by invertebrates; (2) dodder transmission; and (3) pathogen-vector-plant ralationships. In the toxin study, a large number of *Tetranychus tumidus* was introduced to coconut and veitchia palms in the screenhouse for over 18 months. A parasitic dodder, *Cuscuta compestris* was established from diseased coconut palms to the periwinkles in an attempt to transmit the agent. The pathogen-vector-plant relationships were based on the pathogen being a mycoplasma-like organism and the vectors being the homopteran insects. Motor driven flight traps within palm plantings, and sticky traps within

palm canopies have been employed to study the insect fauna present in coconut palms. Over 70 species of leaf-hoppers and plant hoppers were found on the traps. A few species of these insects have been experimentally proven to feed on the palms with *Haplaxius crudus* most predominent. Techniques have been devised to rear *H. crudus* without the use of soil. The biology of *H. crudus* was studied at 15°, 24° and 30°C. Partially purified and crude phloem sap were utilized along with direct feeding of the insects *H. crudus*, *Oncometopia nigricans*, *Macrosteles fascifrons*, and *Hortensia similis* on the diseased palms. The diseased phloem sap was artificially fed and needle injected into adults and nymphs of *H. crudus*, *O. nigricans* and *M. fascifrons*. These insects were then allowed to feed on healthy palms and other hosts. Other plants such as lettuce, tomato, periwinkle, pepper, aster, marigold, and carrot were used as test plants in hopes of finding an alternate host for the pathogen. Techniques were successfully developed to culture coconut embryos on liquid and agar media. Vector tissue culture is currently under investigation.

HISTOPATHOLOGY OF ROOTS OF COCONUT PALM AFFECTED WITH ROOT (WILT) DISEASE

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Anatomy of roots from healthy and diseased coconut palms were studied using serial microtome and free-hand sections. Some externally healthy roots from apparently healthy, and obviously diseased trees (naturally infected) from an area of active disease spread showed poorly staining mechanical and vascular tissues. Walls of tracheary elements were thinner and disorganized. Tyloses occurred occasionally in metaxylem vessels. Several roots revealed degenerate phloem. Necrotic effects were shown by abnormally and deeply staining phloem with dense contents. Tissue degeneration was less pronounced in metaphloem. Many healthy looking roots from apparently healthy and diseased palms had fungal hyphae (?) in metaxylem. Sections of roots with external lesions of the burrowing nematode *Radopholus similis* revealed the presence of nematodes and their eggs in cortical burrows. Such burrows contained deeply staining cells encircled by abnormal sclerenchyma. Degenerative changes in conducting elements could derange the flow of nutrients and thereby contribute to root death due to starvation.

TWO NEW COCONUT PALM DISEASES IN THE NURSERY AND ON YOUNG PLANTATIONS IN IVORY COAST

J. L. RENARD, D. MARIUS, J. P. MORIN, AND G. QUILLEC

Institut de Recherches pour les Huiles et Oleagineux, Plantation Robert Michaux, B. P. 8, Dabou, Ivory Coast

Two new coconut palm diseases appeared in 1971 in mid Ivory Coast, dry heart rot and blast. In dry heart rot, base of the spindle and the bulb appear brown coloured and cork like. The growth of the palm is slowed down, the spindle dries up, the leaves turn yellow, the roots rot slowly, and the plant dies. Blast is characterized by a damp rot of roots and spindle, a brown ng of the lower leaves and rapid death of the plant. These two diseases are found mainly in the nursery and in the first year of planting. Studies have shown that these diseases are related to insect populations as no disease appeared when the plants were placed in a closed cage. Further in the shaded areas where there were practically no insects, incidence of the disease was low. Treatment with Temik also prevented the appearance of dry rot. Varieties did not show any differences in their sensitivity to the maladies. Effective control methods consist of reducing insect populations by shading, insecticide treatment, complete weeding of nurseries.

INVESTIGATIONS ON THANJAVUR WILT OF COCONUT IN TAMIL NADU

T. JAGANATHAN, K. M. VIJAYAN, K. T. SUBBA RAJA, AND R. RAMASAMI

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The results of experiments conducted at Muthupet on Thanjavur wilt of coconut have been reviewed. The disease is spreading from the coastal areas of Thanjavur district to the interior areas. It appears to be a complex disease in which the fungus *Ganoderma lucidum* is also involved in the final stages. Disease syndrome and epidemiology of the disease have been described. Increased level of N, P, and K fertilisers enhanced the disease intensity. The disease was aggravated by the attack of beetles and weevils and these have been reduced by treatment with heptachlor. Summer irrigation was found to be beneficial in reducing the disease. Quarterly application of Bordeaux mixture was effective in controlling the disease. The ameliorative effect of tank silt and green leaves along with Bordeaux mixture has been reported.

UNCERTAIN ETIOLOGY DISEASES OF THE COCONUT PALM

KARL MARAMOROSCH

Waksman Institute of Microbiology, Rutgers University, New Brunswick, N J., 08903, United States of America

The present status of rickettsia like and mycoplasma like diseases of plants and their relevance to coconut palm diseases will be discussed. Certain plant diseases, earlier grouped together with virus diseases, are caused by viroids, spiroplasma, mycoplasma, or rickettsia-like agents. Electron microscopy techniques have been used in several instances, including coconut lethal yellowing disease, for the visualization of mycoplasma microorganisms. Tetracycline chemotherapy gave additional support to the mycoplasma etiology of lethal yellowing disease. In other instances, electron microscopy revealed the presence of artifacts, or of particles such as phytoferritin. The etiology of Kerala wilt of coconut palms is still uncertain. Interactions between disease agents, plant hosts, and insect vectors can be manipulated so as to prevent spread of diseases, even if the etiology is uncertain.

HART ROT - A COCONUT DISEASE OF SURINAME ASSOCIATED WITH A TRYPANOSOMATID FLAGELLATE

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Hart rot, which has also been called lethal yellowing, bronze leaf wilt, Coronie wilt, and "unknown disease" was first reported in Suriname in 1906. The disease exhibits many but not all the symptoms of lethal yellowing that has decimated coconut palms in the Caribbean Islands, West Africa and Southern Florida. None of the coconut varieties including "Malayan Dwarf" seem to be resistant to hart rot. Electron microscopic observations of the phloem of affected coconut palms have revealed the presence of trypanosomatid flagellates, identified as the genus *Phytomonas* Donovan, in mature sieve tubes. Since the flagellates were present in large numbers in the expanding inflorescences and leaves of the infected palms, they could be readily smeared on to the glass slides for observations with phase-contrast microscopy. It was possible to keep the flagellates alive for several minutes in sucrose solutions and up to 90 minutes in coconut m lk. Effects of antibiotics on the flagellates were studied both under field and laboratory conditions. The absence of organisms other than flagellates in the earliest symptoms of the disease and the correlated increase and spread of the flagellates in sieve tubes as the disease progresses suggest that the flagellates are pathogenic to their hosts and hence the possible causative agents of hart rot. The disease is thus quite distinct

from lethal yellowing. The death of an affected palm is presumably caused by the plugging of the sieve tubes by the flagellates.

USE OF OXYTETRACYCLINE FOR PROPHYLACTIC AND THERAPEUTIC TREATMENT FOR LETHAL YELLOWING IN FLORIDA

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Tetracycline antibiotics have been found to be of both prophylactic and therapeutic benefit when injected to coconut palms either threatened or affected by the lethal yellowing disease. Oxytetracycline-hydrochloride was approved for use as a control agent against lethal yellowing by the United States Environmental Protection Agency in June, 1974. Since that time some 25 million grams of oxytetracycline -HCl have been distributed for lethal yellowing treatment in Florida. The coordinate prophylactic use of oxytetracycline-HCl has prevented new development of lethal yellowing in three Florida countries during the past 2½ years. In other areas where antibiotic use was discontinuous or erratic, lethal yellowing has continued to spread. However, coconut plantings receiving regular prophylactic treatment for the past 2½ years are still intact in the Miami area, eventhough all surrounding untreated coconut palms within a 10 km radius are dead. The therapeutic efficacy of oxytetracycline-HCl used at 4-month intervals is 50%. This might be increased if applications are made at monthly intervals in order to maintain high foliar titers of antibiotic until a full remission is evident. Variations in translocation of antibiotic among individual trees may account for the observed responses of diseased coconut palms to oxytetracycline therapy.

DEVELOPMENT PROGRAMMES

Friday Forenoon
31-12-1976

1. PK Thampan, Directorate of Coconut Development, Cochin 682 011, Kerala State, India.

2500 words — The coconut profile of India.

2. MRN Rao, Department of Agriculture, Port Blair 744 101, Andamans and Nicobar Islands, India.

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THE COCONUT PROFILE OF INDIA

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India contributes 15% of the area and 20% of the production of coconut in the world. Despite this, the per capita availability of the commodity in the country is a low 11 nuts per year. Owing to ecophysiological restrictions, the cultivation of coconut is confined to the coastal belts in the country. Though the per hectare productivity of coconut in India is comparable to that of other major producing countries, the per palm productivity and the unit output of copra are comparatively low. The production of coir and coir products constitutes 54% of the world output and the country has monopoly in the production of white fibre. Only 35% of the production of coir products enter the export trade and it accounts for 27% of the total export trade in the world. The milling industry in India is well organised and the entire quantity of coconut oil produced in the country is absorbed in the domestic market. The present annual production is 300,000 tons milling copra, 25,000 tons edible copra, and 200,000 tons coconut oil. The end use pattern for coconut oil is in the ratio 40 : 60 edible-nonedible end uses. Significant progress has already been made in the wet, processing of coconut. A commercial plant with a daily intake of 100,000 nuts is being set up in Kerala State utilising the technology of modified Solvol Process. The only single factor that influences the price of coconut oil is the overall availability of fats and oils in the country. The Directorate of Coconut Development located at Cochin under the Ministry of Agriculture and Irrigation, Government of India is the national organisation for plan formulation and coordination of programmes covering development, marketing and processing. The average size of coconut holdings in the country is less than 0.5 ha, 98% of the holdings having only less than 2 ha. The strategy of coconut development is to accomplish the objectives of increasing production through intensive cultivation and expansion of area and of improving the productivity of coconut holdings through scientific utilization of the interspaces between palms. A large number of development programmes are currently under implementation. The two major programmes are hybrid production and the package approach for improving the productive potential of existing palms. The package approach is to bring 120,000 ha of coconut gardens under scientific management programme encompassing the use of quality planting material, adequate fertiliser inputs, irrigation and improved plant protection techniques. The total combined investment for coconut development in the country is around Rs. 1,000 million over a period of 5 years.

COCONUT IN THE ANDAMAN AND NICOBAR ISLANDS

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Coconut groves were observed in Andaman and Nicobar Islands by the first explorers in the 6th century and Nicobarese were described as the coconut eaters whereas the Andamanese seemed to have no knowledge of coconuts. Out of the local varieties, Nicobar Giant has been found to be the most promising variety. Though the agroclimatic conditions are most favourable, coconut is cultivated in a most unsystematic way in the Islands, and more particularly in the Nicobars, and the average annual yield per tree is less than 15 nuts. The total area under coconuts is estimated to be about 19,500 ha. These are owned and enjoyed by the entire community in the Nicobar Islands. Coconut is the staple food of the Nicobarese and also of the pigs they rear. Two-thirds of the production is consumed locally and the rest is exported as copra. The copra is of low quality.

As the land has been mostly unexploited in these Islands, and climate and soil are congenial, the prospects for coconut cultivation in the Islands appear to be very bright.

COCONUT DEVELOPMENT PROGRAMMES OF ANDHRA PRADESH STATE

B. APPA RAO REDDY

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Andhra Pradesh ranks fourth in India with 40,377 ha under coconut cultivation with 97% of the area being confined to the coastal districts. About 20% of the area is irrigated. East Coast Tall (popularly known as Godavari variety) is the only prominent variety. 'Gangabondam' is a semi-tall variety. The production of coconut is estimated at 173 million nuts annually. A brief account of the cultivation practices is given. Most of the produce is marketed as dry nuts while the rest is marketed as tender nuts. Only about 3% of the entire coconuts produced is utilised locally and the remaining is exported outside the state. There are only a very few coconut based industries in the state.

The first coconut development scheme started functioning on 11-10-1958 with five nurseries. At present eleven nurseries are functioning. They use 4,00,000 nuts annually for raising seedlings.

COCONUT CULTIVATION IN GOA

FERNANDO do REGO

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Coconut is the most important crop of Goa, after paddy, occupying an area of 18, 000 hectares. It occupies the fifth place among the coconut producing states. Its cultivation is confined mostly to the coastal sandy soils. The two varieties cultivated Benaulim and Calangute are both tall types. Dwarf and hybrid varieties have now been introduced. The cultivation practices followed are discussed. The developmental programmes were initiated in 1962-63 after Goa's liberation and introduction of the Five Year Plans. The various development programmes are the distribution of quality seedlings for rejuvenation of old gardens and establishment of new ones, new areas brought under cultivation, minor lift irrigation schemes established, a fertiliser consciousness built up among the farmers, and prophylactic measures against pests and diseases. These have been responsible for an increase in production from 70 million (1961) to 97 million nuts (1974).

COCONUT DEVELOPMENT IN GUJARAT STATE

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The first coconut development scheme in Gujarat was started in April 1965. Since then the programmes consisted of: raising and distribution of coconut seedlings at subsidised rate; advancing long term agricultural finance for coconut cultivation; establishing coconut demonstration centres and laying out exploratory plots on cultivators' fields; rejuvenation of old coconut trees; and allotment of government waste land near sea coast for coconut cultivation. The details of these schemes are given.

It is now estimated that nearly 8100 ha of area is under coconut crop and annual production is about 200 million nuts. Ripe nuts only are harvested at Mahuva and Valen, while tender nuts are harvested in rest of the area. No coconut based industries are now operating in the State. The outlook for coconut cultivation and development is given.

COCONUT CULTIVATION AND INDUSTRY IN KARNATAKA STATE

YESHWANT AIL

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Karnataka is the second largest coconut growing state in India. The total area under coconuts is 1,81,000 ha and annual production is 135 million nuts. In the State, coconut is grown from the sea level upto an elevation of over 1000 meters. The soil and climatic conditions of growth are highly variable. A brief account of the cultivation practices in the various coconut tracts of the State is given.

Detailed accounts of the various development programmes which are operating in the State are given. These consist of, establishing elite seed farms for producing hybrid coconuts at Kannamangala and Bellare, production and distribution of quality seedlings, field trials for control of *anabe roga* and an ARC–financed scheme to improve coconut cultivation.

The coconut based industry consists of extraction of oil both in villages and also in large rotary mills, production of coir fibre, ropes, mattresses and carpets with about 54 factories engaged in it, production of coconut shell powder, etc.

The prospects of coconut cultivation and industry in the State are discussed.

COCONUT DEVELOPMENTAL ACTIVITIES IN KERALA STATE

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The coconut development programmes in the State starting from the demonstration plots in farmers' gardens in 1940s, to the current package programmes financed by the Centrally Sponsored Scheme, pilot projects for rejuvenation of root (wilt) diseased coconut gardens, scheme for the production of T × D seedlings, schemes for providing irrigation in coconut gardens and schemes implemented by the Agricultural Refinance and Development Corporation are described.

COCONUT DEVELOPMENT PROGRAMMES IN LAKSHADWEEP

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The entire cultivable area of 27.60 sq. km in Lakshadweep has been occupied with thick coconut plantations. About 90% of the people depend upon coconut

for their livelihood. The total palm population is estimated to be about 0.60 million with an annual production of 21.4 million nuts during 1975 – '76.

During the Second to Fourth Plans, the development programmes consisted of distribution of quality coconut seedlings and fertilisers. About 90 fertiliser demonstration plots were also laid out. These plots produced 2 5 times more yield than the control plots. Rats and rhinoceros beetle are a major problem in the islands and they are being regularly controlled through massive campaigns.

The present development programmes consist of control of pests and diseases, recommending improved cultural, manurial and intercropping practices, distribution of fertilisers at subsidised cost, and distribution of power tiller at 50% subsidised cost. These are discussed in detail.

COCONUT DEVELOPMENT IN ORISSA

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In Orissa, the area under coconut has increased from 6,400 ha in 1955 to 11,340 ha in 1975 with a production increase from 12 million to 43 million nuts per annum. The yield has increased from 12 to 22 nuts per palm Eighty per cent of the area is concentrated in the four coastal districts, Cuttack, Puri, Balasore, and Ganjam. Establishment of the Coconut Research Station at Sakhigopal in 1948 under the auspices of the Indian Central Coconut Committee was the first step in organising scientific coconut cultivation in the State.

The coconut extension programmes which were initated with financial support from Indian Central Coconut Committee include raising of quality seedlings in departmental nurseries, demonstration of package of practices in farmers' field, and financing of coconut cultivation through the Agricultural Refinance and Development Corporation. Coconut plantations have been extended in paddy field bunds, canal embankments and coastal sand dunes have been extended. A comprehensive hybrid seednut production programme is being executed in five sub-stations. A parasite breeding and biological control programme has been built up. To preserve the indigenous coconut germplasm an isolated plantation is being organised in a reserve forest. Marketing facilities for coconut and industrial utilisation of the by-products are rather inadequate in the State. It is programmed to double the area under coconut and attain an average yield of 50 nuts per adult palm within the next decade.

COCONUT IN TAMIL NADU

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A brief review of the various coconut development schemes implemented in the State of Tamil Nadu and their impact on production are presented in this paper. The State has an area of 109,000 ha under coconut with a production of 1,091 million nuts per annum. There has been an increase of nearly 20% in area and 30% in production between 1965 and 1975. The average yield per palm per annum rose from 45 nuts in 1965 – 66 to 55 nuts during this period. About 1.13 million quality seedlings are distributed annually from the 24 nurseries run by the Department of Agriculture. Financial assistance is extended to growers in the form of long and short term loans for establishing new gardens. A coordinated scheme for the improvement of existing gardens is also being implemented. Nearly 1,000 pilot demonstrations have been laid out between 1969 – 70 and 1975 76 throughout the state for demonstrating the efficacy of improved practices. A scheme for the establishment of new coconut gardens was implemented in Ramanathapuram district and over 5,000 ha of new gardens have been established. The Department has established a chain of 16 parasite breeding centres for the control of the *Nephantis serinopa*. Investigations on the complex wilt disease has been taken up at Thambikottai area of Thanjavur district. The scope for the expansion of area and improving the production in existing gardens are also briefly brought out.

COCONUT DEVELOPMENT ACTIVITIES IN WEST BENGAL

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The area under coconuts in the state in 1947 was 6,600 ha and annual production 22.2 million nuts. The state government with support from the Indian Central Coconut Committee implemented two nursery schemes during the First Five Year Plan and one coconut development scheme during the Second Plan. During the Third Plan these schemes were merged into one. Starting from a scratch, 55 big and small nurseries have been functioning in the state and they have been distributing 1.5 lakh quality seedlings each year. Besides an extension of area, the scheme aims at educating the growers to adopt improved cultural practices. The present area and production may be estimated to be 36,000 ha and 130 million nuts. Seventy per cent of the nuts are harvested at tender stage for the coconut water. This adversely affects the development of associated industries.

DEVELOPMENT PROGRAMMES OF COCONUT IN SRI LANKA

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The coconut area comprises about a third of Sri Lanka's cultivated land. The total production of coconut in Sri Lanka in 1974 was 2,044 million nuts. Sri Lanka is the fourth largest producer of copra in the world and coconut is the third largest foreign exchange earner next to tea and rubber. The major coconut products exported from Sri Lanka are copra, coconut oil, desiccated coconut, and fresh nuts. Four independent Boards under the overall control of Coconut Development Authority take care of research, cultivation, processing, and marketing aspects of coconut. The drop in production and the steadily increasing domestic consumption have posed the problem of a continuous decline in future exports. The solution seems to lie in replanting with higher and quicker yielding varieties.

AN ASSESSMENT OF THE COCONUT INDUSTRY OF MALAYSIA

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Coconuts rank as Malaysia's fourth largest crop in terms of acreage covering about 532,00 acres or 7% of total cultivated land area. About 90% of the total coconut acreage in Malaysia is under small holdings. Out of an estimated total of 70,000-80,000 coconut small holders, about 17,000 are in poverty group.

The problems connected with the Malaysian coconut industry are low productivity due to poor management and cultural practices, the use of unselected varieties, lack of adequate research for the improvement of the crop and the industry, the sociological problems associated with a large number of small holders dependant on a low income crop, uneconomical size of holdings, and the absence of a good marketing system. In the light of these problems the government has taken some measures to improve the industry and raise the income of the small holders.

An assessment of the industry and the government's corrective measures is made to throw greater light on the problems faced by the industry.

RESEARCH AND EXTENSION: THE KEYS TO COCONUT DEVELOPMENT IN JAMAICA

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The development of the coconut industry of Jamaica over the past two decades is described to show the advantages of decentralising the responsibility for development of a crop to a specialised agency in which research, extension work, marketing and farmer services, can be vertically integrated. Significant items of development are: (i) a market for coconuts in any quantity; (ii) a fund for hurricane insurance; (iii) testing and propagating the disease-resistant 'Malayan Dwarf' to replace the susceptible local Tall; (v) initiation of an industry-financed replanting scheme; (v) development of rain-repellant baited rat poison; (vi) a complete herbicide research programme culminating in recommendations to farmers; (vii) identification of responses of coconuts to major fertiliser elements on main coconut soils; (vii) provenance of a disease-resistant hybrid and development of techniques to produce plants in quantity; and (ix) delivery of plants, fertiliser, herbicide, and rodenticide to farmers.

DEVELOPMENT PROGRAMME FOR THE COCONUT INDUSTRY OF THE PHILIPPINES

JUAN T. CARLOS, JR.

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The characteristics of the Philippines coconut industry, including its present status, future plans, and prospects are discussed. Some details on the economics of the industry, varietal development, re-planting programme, nursery practices, fertilisation, cropping systems, and pests and diseases are presented. Priority research areas, current and proposed researches, and research needs for the industry are also included.

THE POSITION OF COCONUT IN THE WORLD ECONOMY

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— Abstract not received —

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